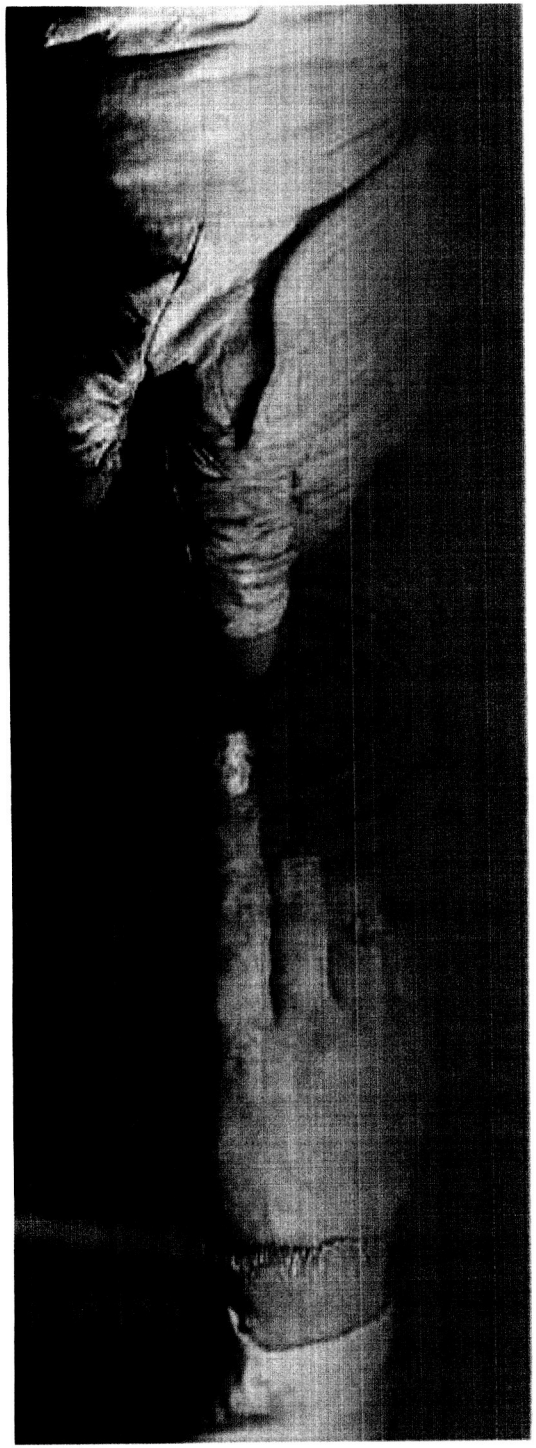

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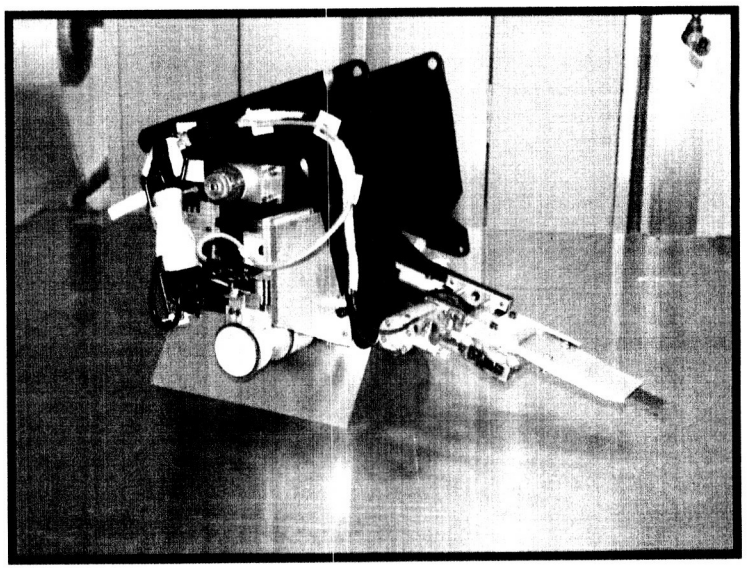
Film Processing Module for Automated Fiber Placement



Bruce Hulcher
NASA Marshall Space Flight Center

NASA Technology Briefings

May 19, 2004

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Outline

1. Introduction and Background
2. Fiber Placement Process Description
3. Technology Benefits
4. Technology Description
5. Technical Details
6. Technical Advantages
7. R&D Status
8. Remaining Work
9. NASA Plans/Options
10. NASA's Tech Transfer Program
11. Acknowledgements

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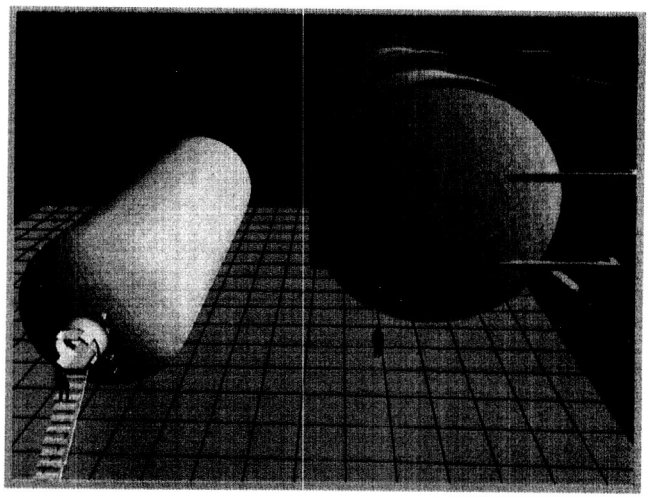
Introduction and Background

- Composite Processes and Fabrication Team, MPM Dept.
- Recent work focused on 2nd Gen RLV & NGLT Technology
- Micro-cracking/Permeability Issues for Liquid Cryogen Tanks
- Fabrication Trade Studies for Very Large Composite Tanks



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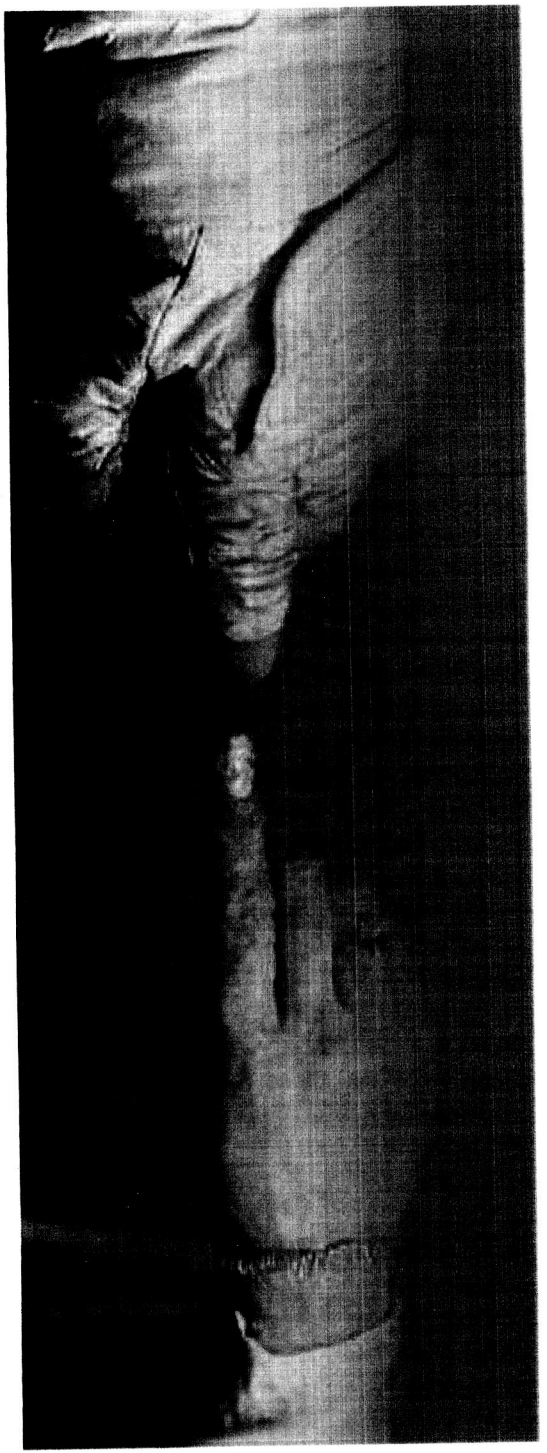
Introduction and Background: Genesis of Concept

Team Focus: *Reusability of Propellant Tanks*

- Micro-Cracking of Polymer Matrix Due to Thermal Cycling
- Manufacturability Issues: Out-of-Autoclave, Tooling Concepts, etc.
- Studies: Permeability of Various Polymers/Films to LOX, LH

Not Captured:

Fabrication of Structures Having Barrier Films/Foils and/or Core Adhesives ⇨ Scale: Technology for Manufacturing of Large (30 ft. x 90 ft.) Propellant Tanks



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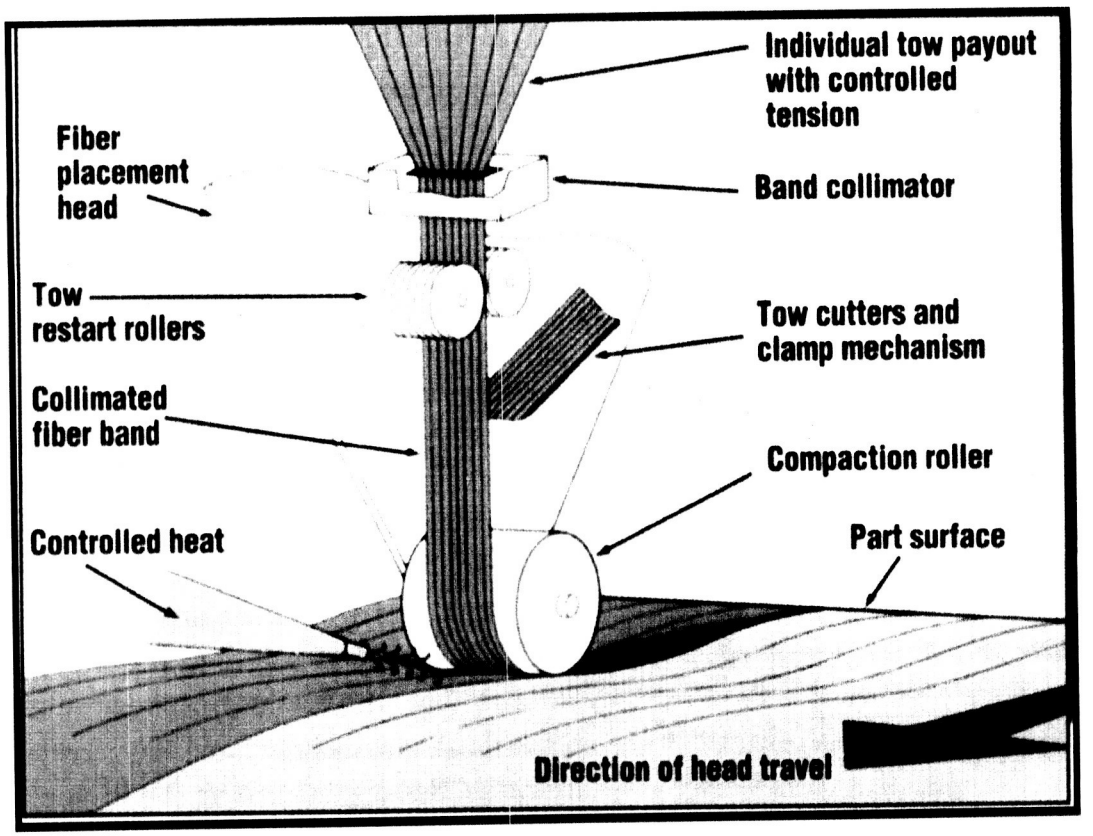
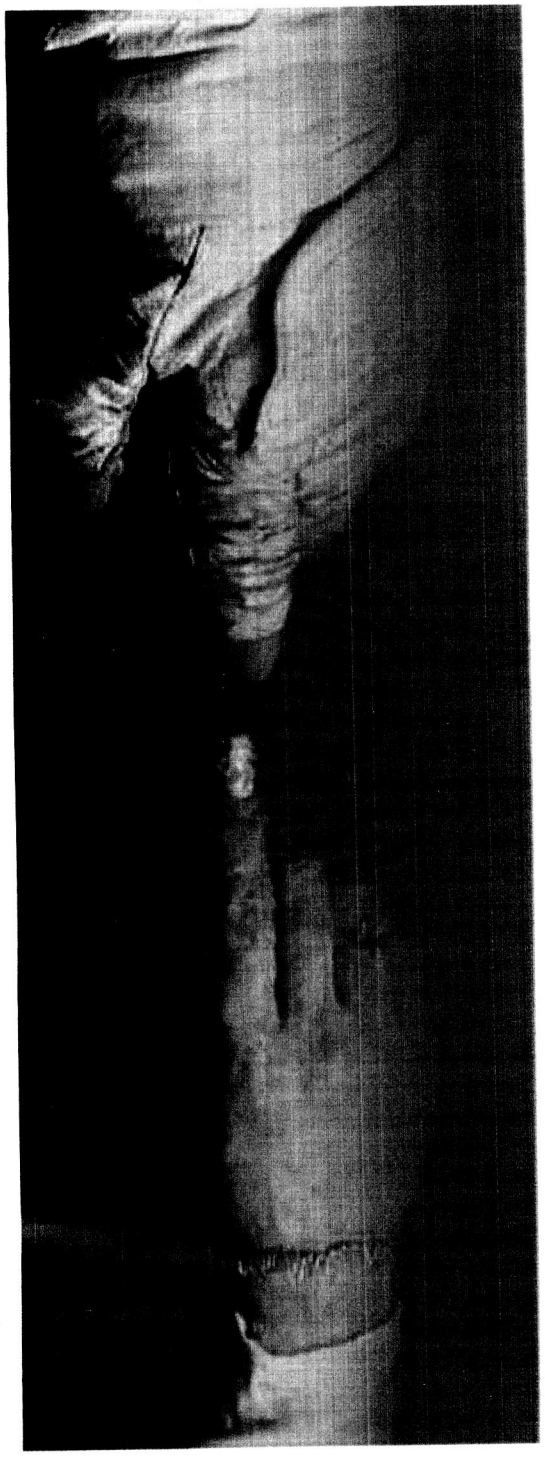
Fiber Placement Process Description





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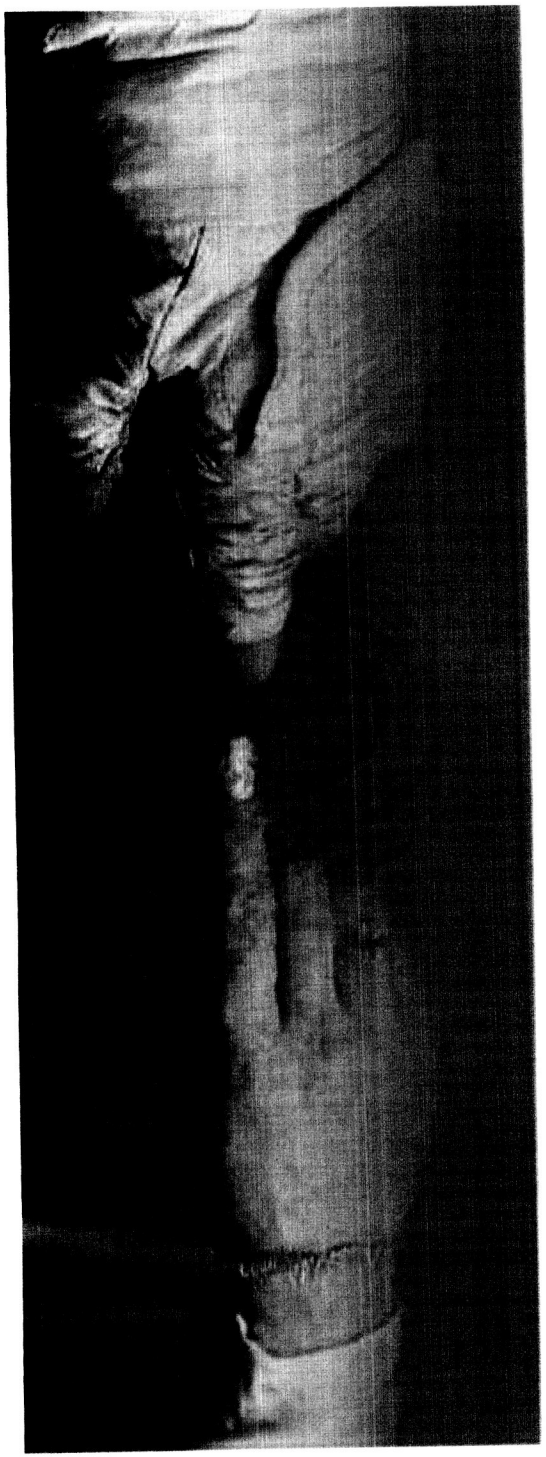
Technology Benefits

- Enhancement of the Fiber Placement Process
- Simultaneous Placement of Films/Foils into Laminate During Ply Lay-up Cycle or as Separate Step
- Device May Be Designed as Add-On or Integrated into New Fiber Placement Machinery
- Ease of Attachment and Removal of Module to Host Machine
- Slave-Control Operation for Ease of Integration
- Reduction in Part Costs due to Reductions in Cycle Time
- Capability Extends to Automated Deposition of Core Adhesives



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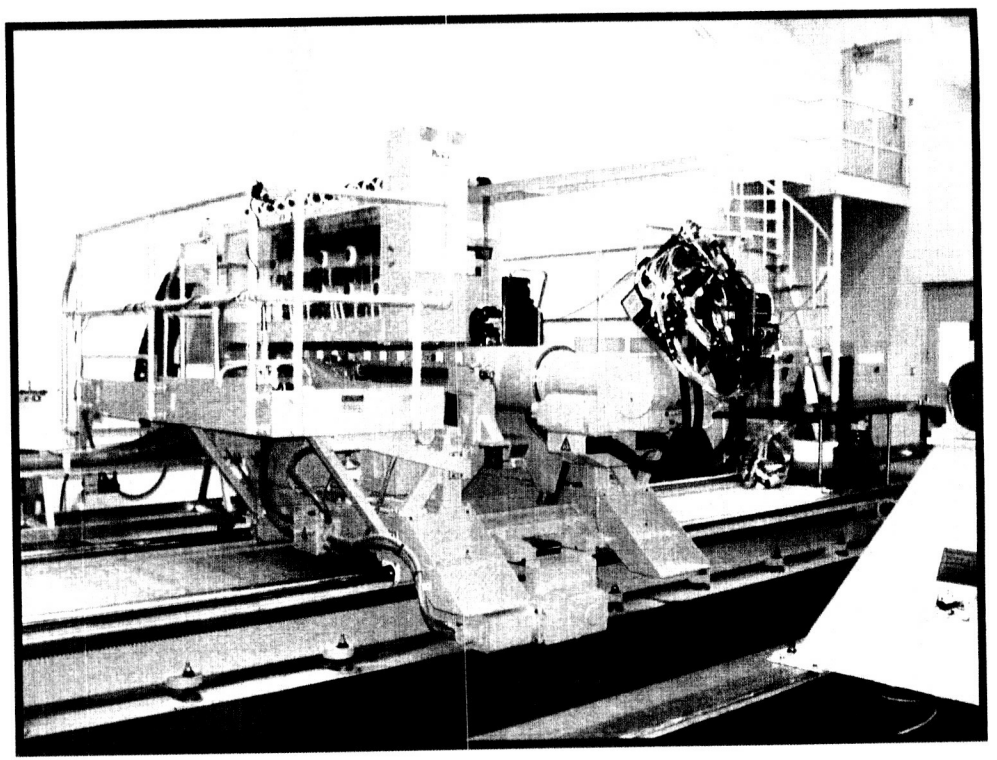
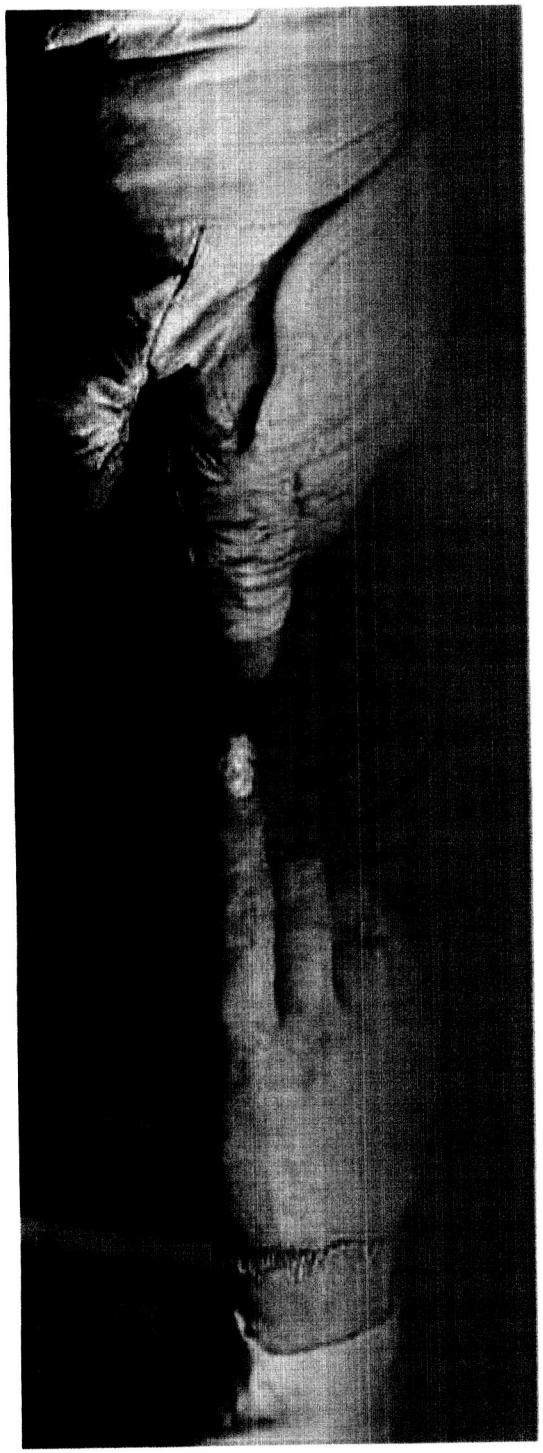
Technology Definition: ***Prototype Test Bed***



MSFC Fiber Placement Machine



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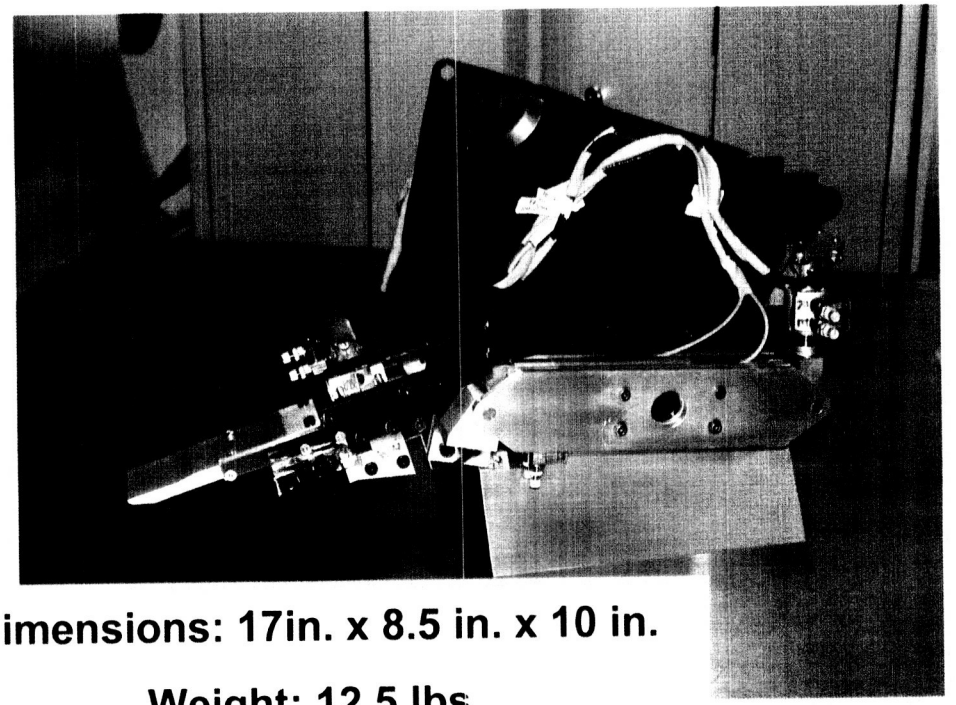
Technology Definition: Module Specifications



Dimensions: 17in. x 8.5 in. x 10 in.

Weight: 12.5 lbs.

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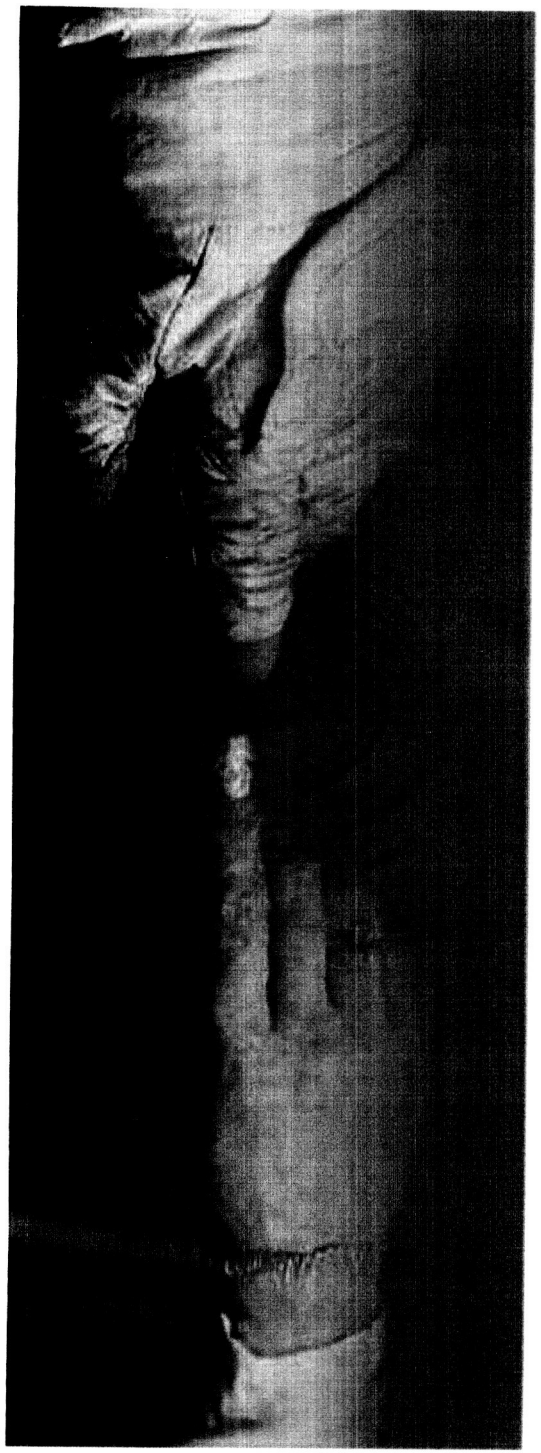
Technical Details: Applications

- Titanium/Graphite Laminates (TiGr)
- Glass/Epoxy/Aluminum Laminates (GLARE)
- Embedded Lightning Strike Protection
- Liners/Permeation Barriers
- Embedded Sensor Arrays
- Adhesives
- Processing



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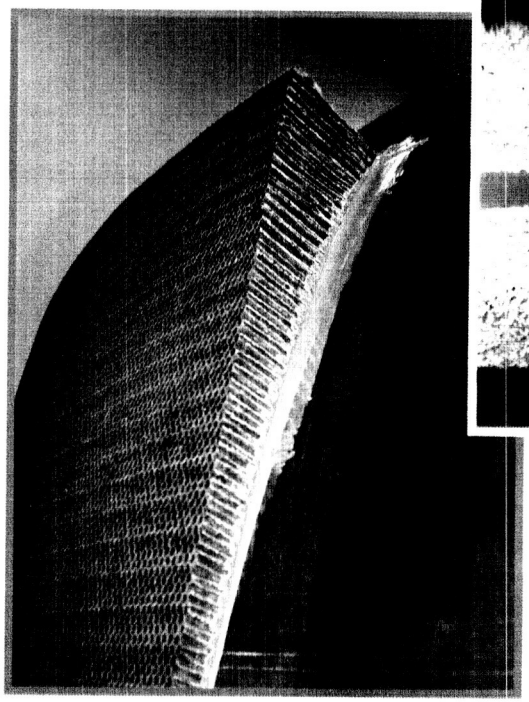
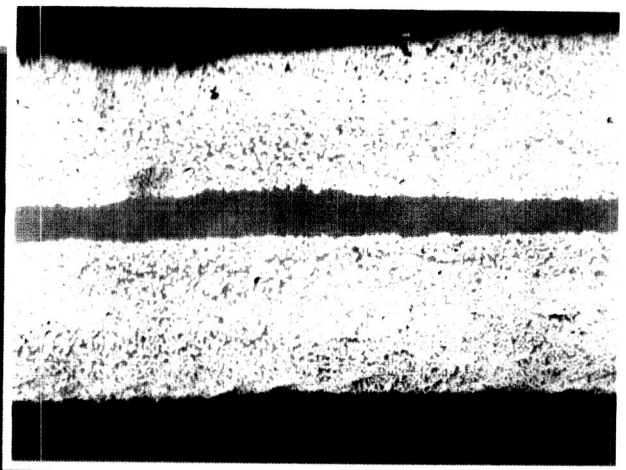
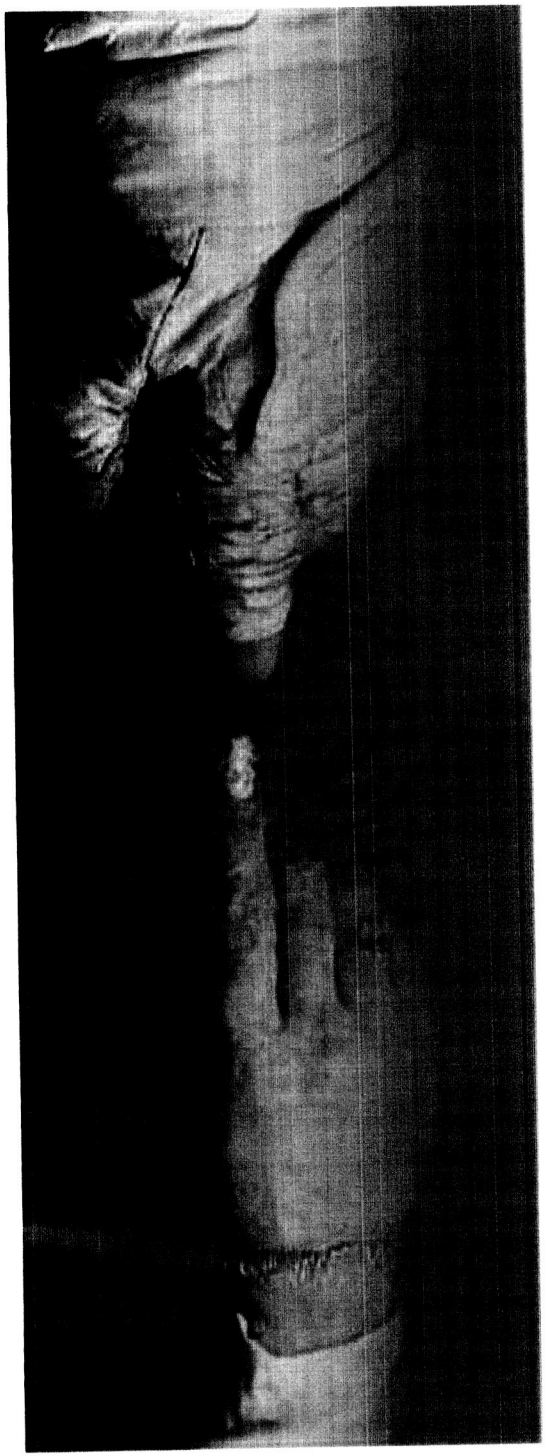
Technical Details: Applications



Core Adhesives



Barrier Layers



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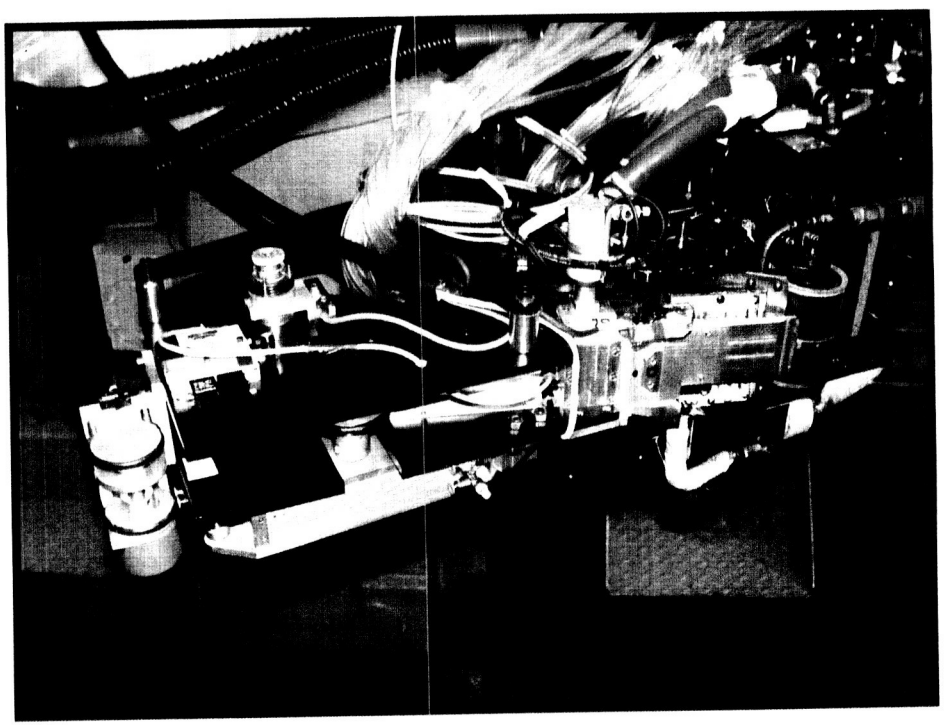
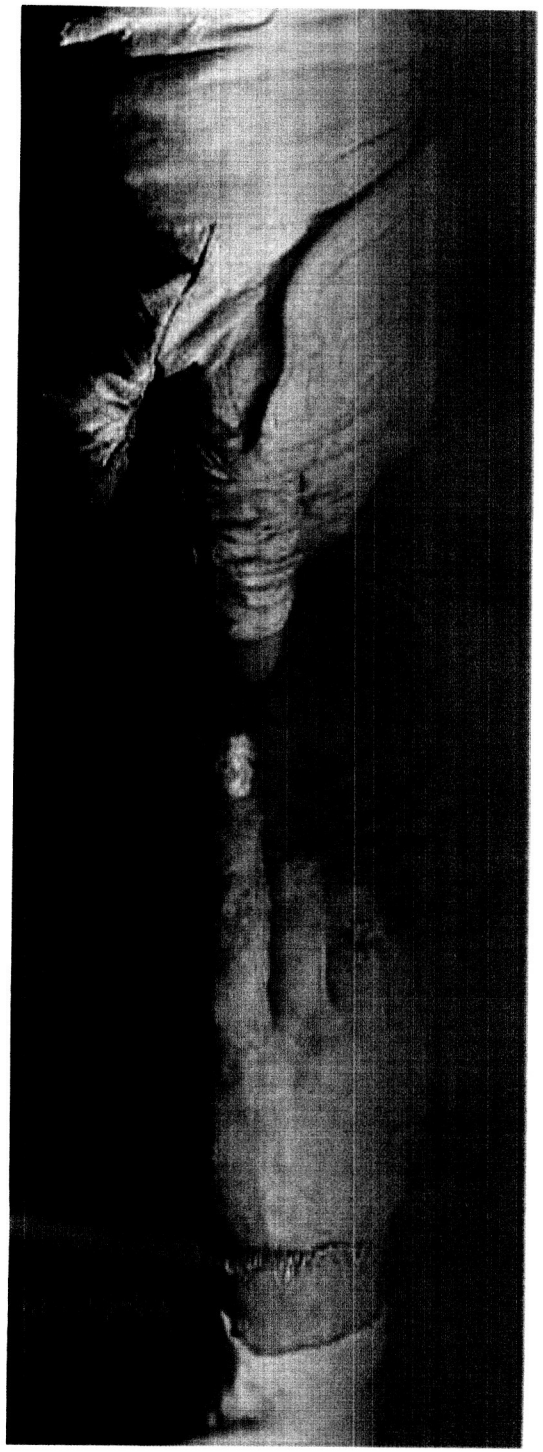
Technical Details: Attachment to FP Head



Film Module On Viper Placement Machine



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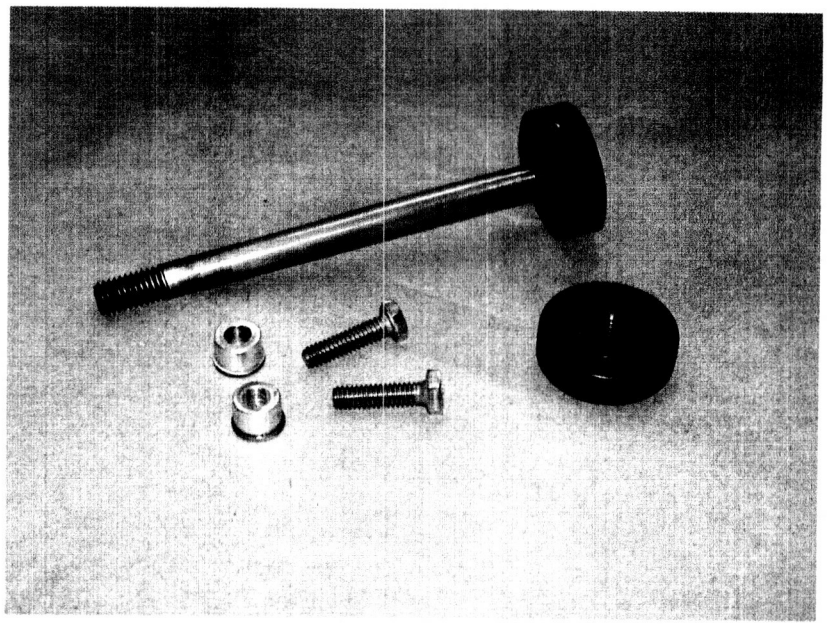
Technology Details: ***Simple Attachment to FPM***



Attachment Hardware for Module

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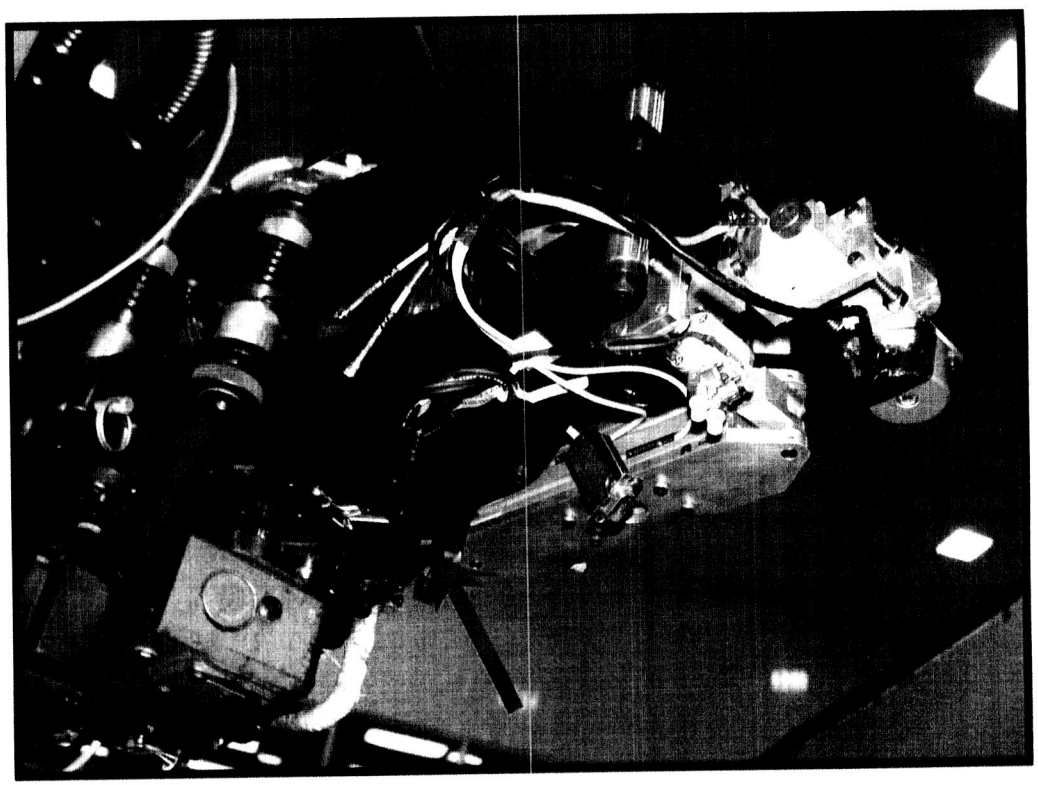
Technical Details: ***Attach Points***



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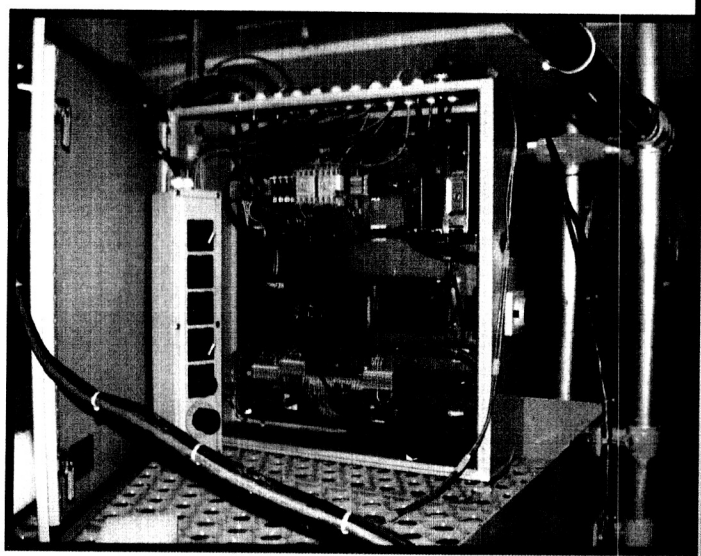
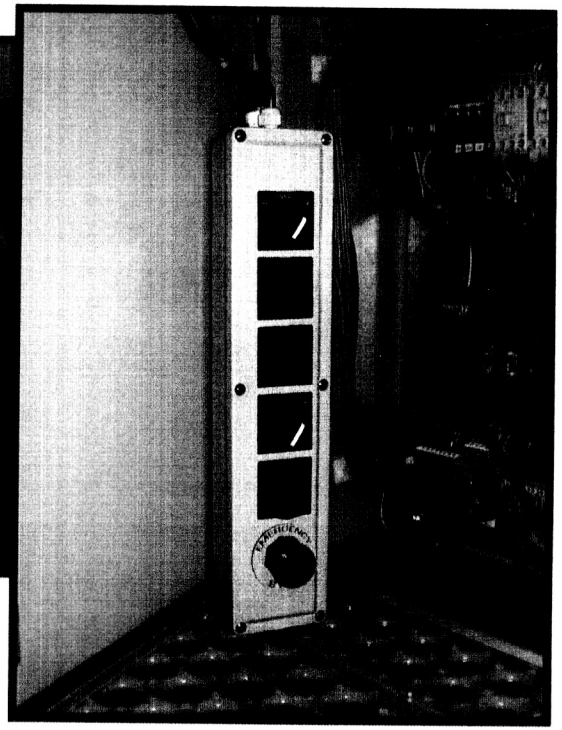
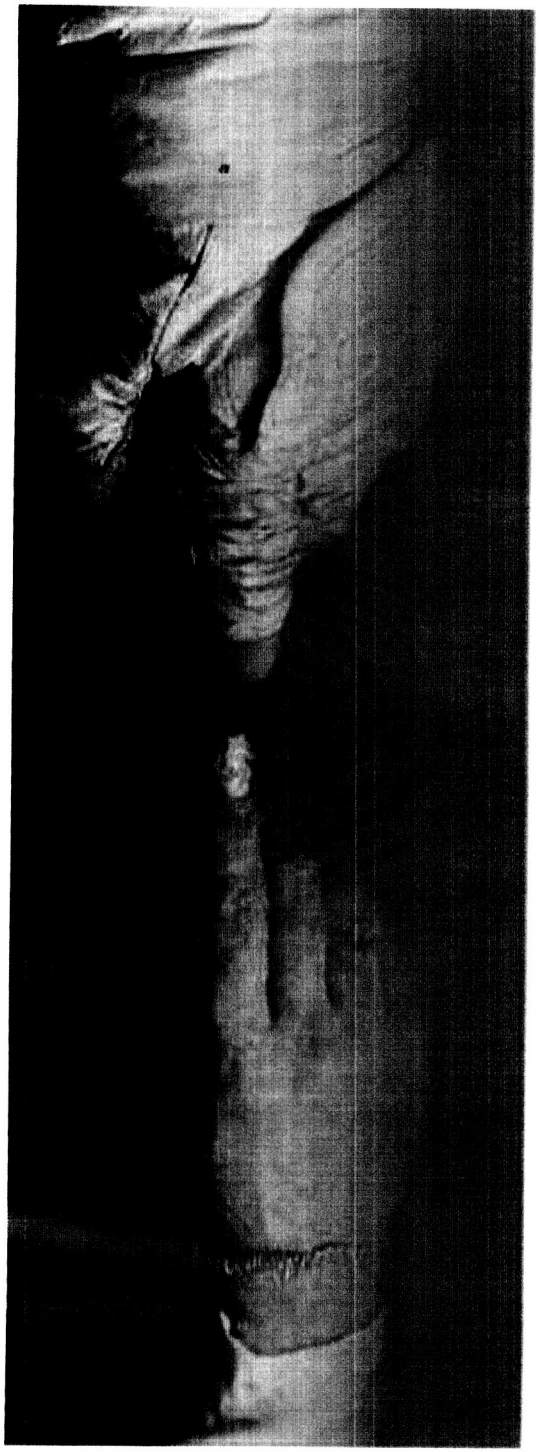
Technical Details: Controls



Electrical Controls Enclosure



Hand Pendant Control



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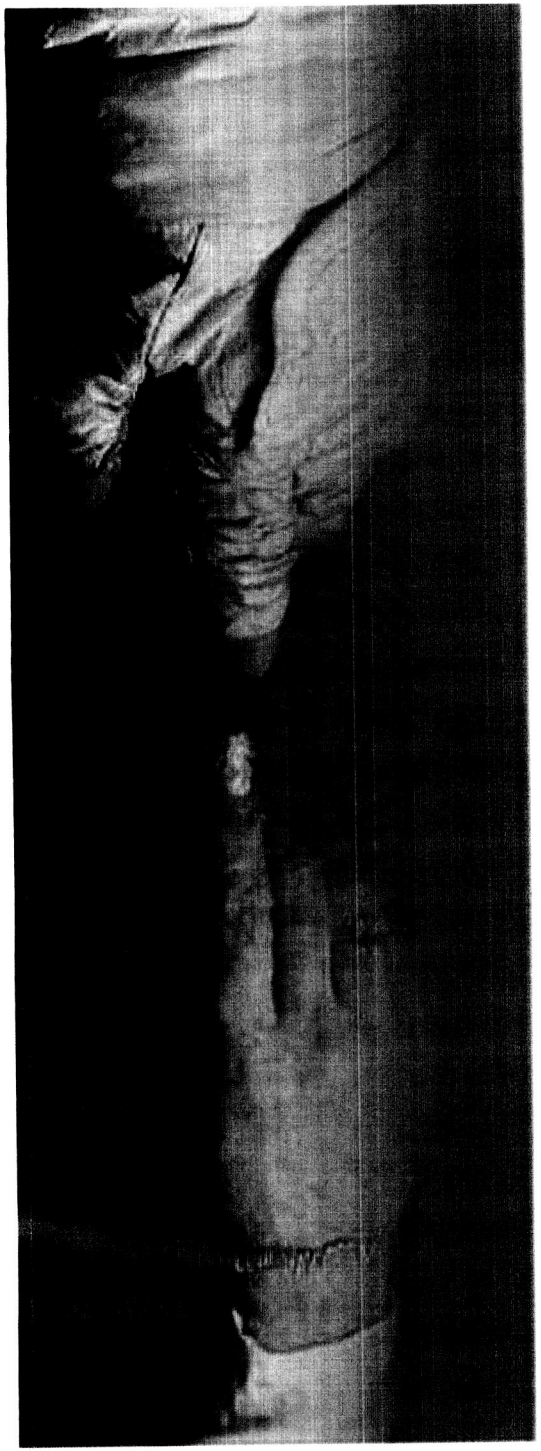
Technical Details: Prototype Specifics

- PLC-Based Controls (ladder logic)
- Fully-Adjustable Device Sequencing and Timing via Speed/Motion Sensor
- Pneumatic Material Feed and Cut System uses Shop Air
- Electrical Power: 120 VAC
- Variable Power IR Radiant Heat Source for Substrate/Film Heating
- Simple Guillotine-Style Material Cutting System with Vacuum Hold
- Uses Host Machine Compaction Roller: May be Designed with Independent Heated Roller and/or Heated Trailing Shoe



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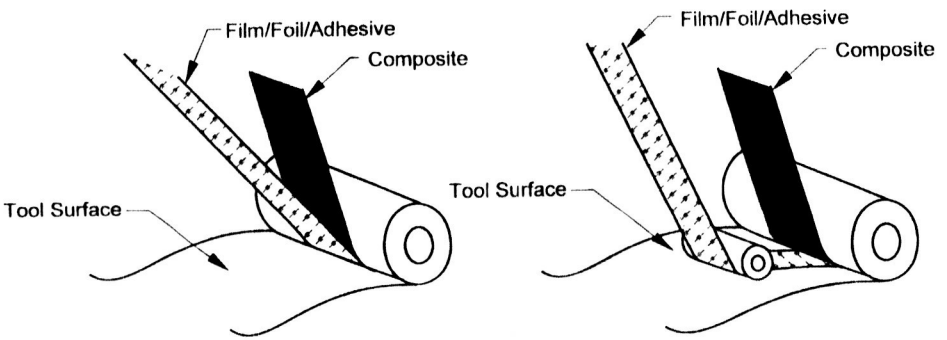
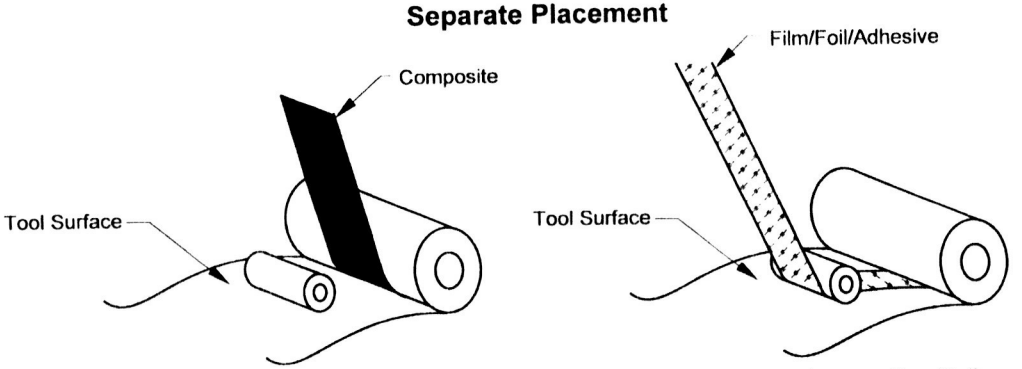
Simultaneous Placement



Shared Compaction Roller

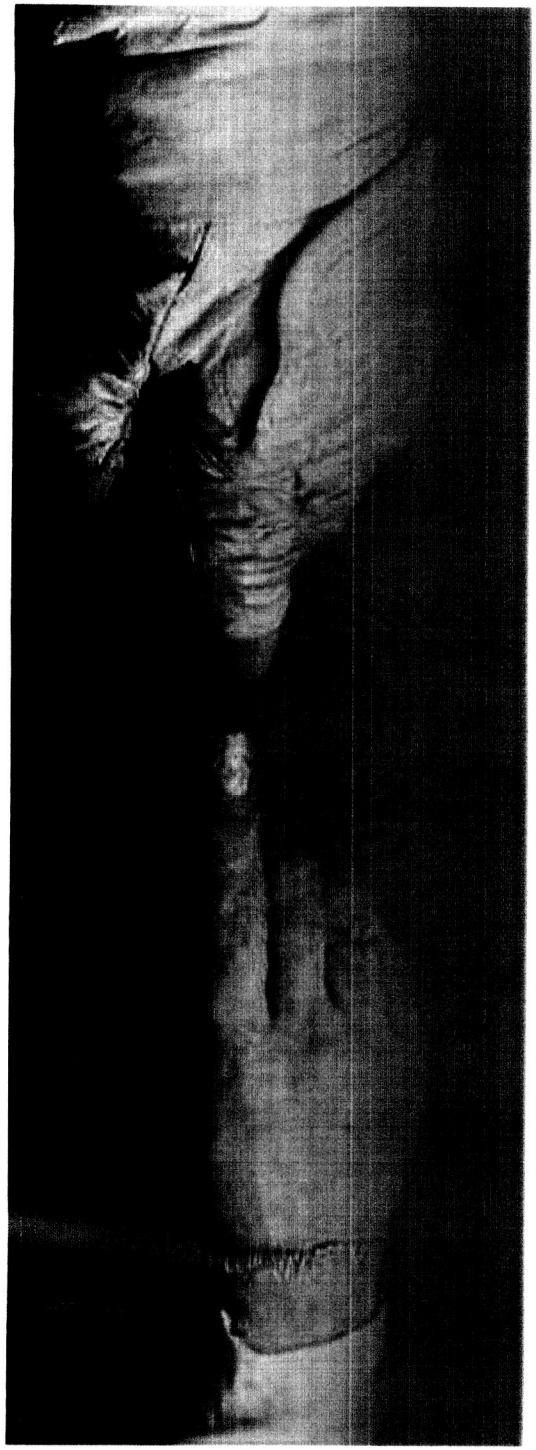
Independent Compaction Rollers

Separate Placement



Independent Compaction Rollers
Composite

Independent Compaction Rollers
Film/Foil/Adhesive



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Technical Advantages

- Reduction or Elimination in Hand Lay-up
- Improvement in Quality
- Reduced Fabrication Costs
- Can Be Added to Existing FP Machines or Designed as Integral (fixed or detachable) for New Machines
- As an Add-On: Slave-Control for use of Existing Placement Files, Minimizing Integration Work
- Quick Attach and Removal from Host Machine
- May Process T/S or T/P Films & Metallic Foils
- Capable of Processing Variable Material Thicknesses and Widths (1in., 3 in., etc.)

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R&D Status

Engineering Prototype Designed for Demonstrations

And Testing at MSFC

Prototype has been Bench-Tested and Fit-Checked to Viper Placement Machine

Remaining Work:

Full-Scale Processing Demonstrations

Remaining Work: Initiate Processing Trials

- Simultaneous and Separate Placement of Films and Composites
- Trials Using Materials of Different Thicknesses
- Trials with Metallic, Aluminized and Polymeric Films
- Overlap/Gap Studies
- Analysis and Mechanical Property Evaluations
- Publication of NASA Technical Memorandum

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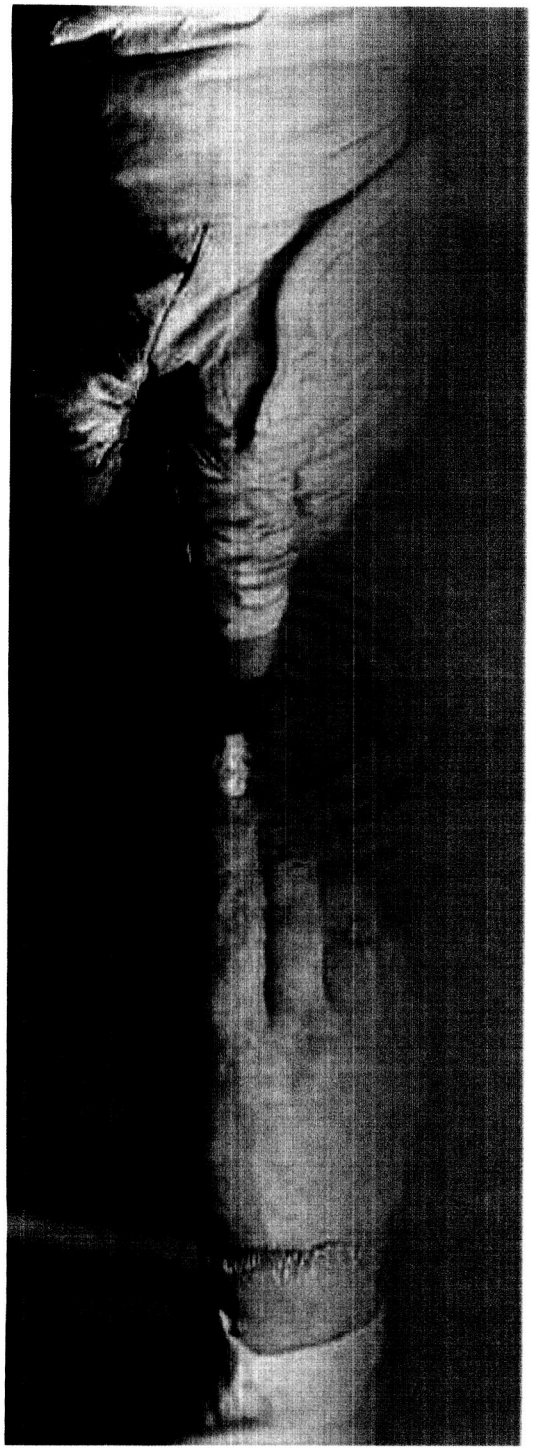
NASA Plans/Options

- Provisional Patent filed May '04
- Non-provisional Patent to be filed June '04
- NASA Seeks Partners to License this Technology



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NASA's Technology Transfer Program

- Program seeks to stimulate commercial use of NASA-developed technology and infuse commercial technology into NASA missions.
- NASA is flexible in its agreements for licensing or partnerships for co-development. Opportunities in patent licensing include exclusive, non-exclusive, or exclusive field-of-use agreements.
- For more information, visit the NASA exhibit or contact Sammy Nabors: NASA/MSFC Technology Transfer, 256-544-5226, sammy.nabors@nasa.gov

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Acknowledgements

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